LCA IN ROBOTICS, NEW CHALLENGES FOR THE FUTURE.

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Abstract

The rise of robotics in the 21st century has changed intensely our relationship with the environment, by affecting the consumption of natural resources and inducing new waste. Nowadays, robots are produced in huge numbers, reaching fleets expressed in millions. Thus, environmental awareness and concerns, in the field of robotics, are critical to incite manufacturers to develop more eco-friendly robots. At this level, the life cycle analysis (LCA) is a useful tool to improve the environmental qualities of robot's components and reduce their impacts. However, LCA in robotics is expensive and complex, because it requires the availability of big amount of data in good quality, all over the life cycle, and hence, implicates all the socio-economical actors who intervene, from the extraction of the raw materials to the end of life of the product. It is also fastidious because it must take into account the impacts generated by the mechanical and electronic components with the data-streams processed by the software platform, which plays a main role in the definition of the hardware impacts and its utilization. In this article, we present in the first part, the results of an investigation performed on 33 French leading robots companies. They have been asked about their environmental considerations and their use of LCA. In the second part, we introduce a case study of a life cycle analysis done on a companion robot. This last was built in the Lab-STICC Laboratory as a solution to help dependant people and assist them in their daily life. The results are discussed and potential improvements are suggested for future works.

Keywords

Robotics, mechatronics, survey, sustainable development, companion robots.

1. INTRODUCTION

The growth of the elderly and dependant people in EU countries will be huge until the middle of the century. One way to maintain the contact with them and assist them is to use communicating systems in their home, particularly companion robots. Today there are some projects of high-tech high-cost robots like Companionable [1] or Romeo [2]. We think that there is a market for high-tech but low-cost robot, with reduced capacity of action, but that can cooperate with other specific robot like vacuum-cleaners, in a context of a local cloud of connected things linked to a home area network (HAN) reachable from Internet. In this perspective we study small robots build with standard components, that can offer several services as the ability to communicate with care givers and the family through video conferencing software, voice recognition, gesture language in case of deafness, catching images, detecting water or other liquids on the floor, even a fall and other dangerous situations. We think that the market will reach quickly a renewal state, and taking into account that the targeted population don't like frequent changes, we look at these robots from the point of view of the LCA.

In the next part, we present the results of a survey of 33 French leading robots companies about the usage of LCA. Then we introduce a case study of a life cycle analysis done on a companion robot. After that we discuss the results, and finally we propose potential improvements for future works.

2. SURVEY OF FRENCH ROBOTICS COMPANIES ABOUT LCA

We performed an investigation on the environmental practices of 33 SYROBO trade union members and other companies or labs we know, see table 1 for the list. The survey is exploratory, it comprises 19 questions, classified in 2 main categories: general information and sustainable development. Most of the asked questions were followed with possible choices of answers, or free filling spaces. Among the questions we wanted to know:

- The manufacturer's robotic field to identify which ones are more or less preoccupied by the environmental practices.
- The integrated environmental strategy of the company and the list of the standards which is committed to, such as: RoHS, WEEE, ISO 140XX, EPEAT, ELV [3], etc.
- The practice of Eco-design of robots and the purposes behind it. We proposed many choices like: energy saving, durability optimization, etc.
- The environmental properties of the robot's components. Among the qualities that we advanced, there are: recyclability, biodegradability, renewability, reusability, etc.
- The life-cycle analysis (LCA): we asked if they evaluate the environmental impacts of their robots, and if they do it for hardware, software or both platforms. We asked them also, how they use LCA, we have particularly focussed on Software LCA since it is not well spread and has an important impact. In this matter we wanted to know the software constraints they are taking into consideration when performing LCA for software. Besides we asked them about the used environmental indicators and LCA tools, in order to detect which ones are more pertinent in robotics.
- Non-functional qualities: we asked the manufacturers about their considerations of reliability, modularity and maintainability and in which level (hardware, software or both) they implement them, because these qualities increase the durability of robots, the reutilization of their components and can prevent waste and obsolescence.

Table 1: list of the surveyed French robotics companies.

Abankos	Aldebaran-Robotics	Awa Bot	BASystemes	CEA-LIST	CRIIF
Delair-Tech	Deltadrone	Eca-robotics	EdF-Intra	Effistore	EOS-Innovation
First Class Robotic	Induct-Technology	Irstea	Mécanuméric (Charlyrobot)	Medtech	M-TecksEAC
Novadem	Overdriverobotics	R&D Tech	RB3D	Robopec	Robopolis
Robosoft	Robotswim	Staubli	Tecdron	Tecknisolar	Violet
Vitirover	Wanyrobotic	Zodiac-Poolcare			

The survey has been created using the online UBO's tool Lime survey. We sent it to the main contacts of the 33 companies and put in place an interval of 1 month from February 2014 to March 2014, in order to receive the answers. After the end of the interval, the survey was closed and we extracted the data in a MS Excel file.

As a result, only one company responded partially to the survey, three others consulted the survey but did not answer and the rest did not even take a look on the survey. The turnout was about 3 % and the interestingness for the survey was about 12 %. R&D Tech France CEO informed us that they build robots for the military field, they have an environmental integrated strategy, they are RoHS certified, they work with eco-design principals in order to reduce raw materials consumption and use recyclable and less energy demanding components in their robots. However, they don't perform the life-cycle analysis for their robots.

We draw up the following assumptions in order to interpret this "sparse sampling":

– These companies don't integrate any environmental concerns in their internal strategy neither the concepts of sustainable development.
– Some issues are confidential, and hence can't be disclosed.
– Some survey's messages were considered as spams by the spam filter in the companies' mail boxes.

Although we can't validate the results at the moment, we have decided to submit again the survey in several months, but giving more explanations and references about LCA in mechatronics and including the expertise of our laboratory sociologists. As well, there will be also a possibility to meet face to face more companies than the three which we have already met.

3. LCA ANALYSIS ABOUT A COMPANION ROBOT

As shown on the right of the figure 1, the components of the robot are chosen off the shelf, except the cover. The robot is build on a mobile platform Rover 5, that includes caterpillars, motors, sensors, wheels, axles, and connectors. Connected to this platform we have a central unit composed by an Arduino board, a Bluetooth module and a relays board. To supply all of theses components we use two sets of 6 AA batteries. On the cover we put a smartphone over Android. The second configuration of the central unit (not shown) is composed by a Raspberry Pi, a WiFi-USB module, and a USB-Phidget module.

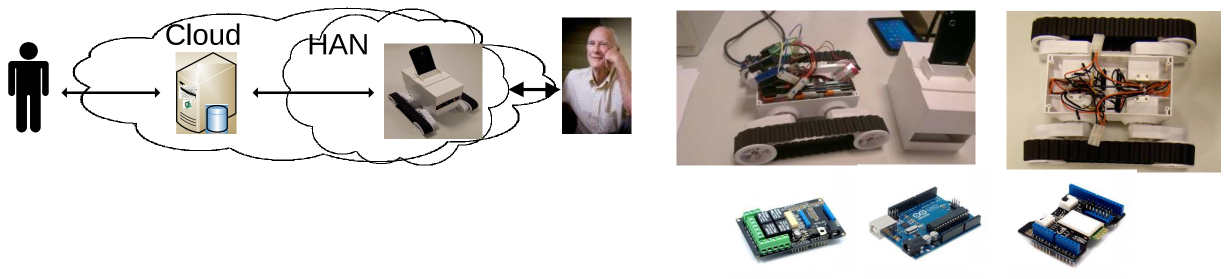

Figure 1: On the left the context of use, on the right the components of the robot.

These two configurations are sufficient to develop the software for the needed services. The goals of the LCA are to reduce the mass of non-recyclable waste, to improve the reuse of the components both material and software, and to quantize the environmental impacts. The aim of the study is to improve the choices during the early design of companion robots. In a previous paper [4] we have explained the used methodology to design the robot, choose the components in respect of performance criteria of the functional unit. This latter is defined as of one year of usage, 1500 km/year, permanent monitoring, a mass of about 3 kg, the size of two shoes on the floor, an ideal MTTR of few minutes, a minimum MTBF of 1 year, the ability to communicate images and sounds through a wireless connection with a bandwidth upper than 1Mbits/s, etc. The boundaries of the system include the mobility platform, the central unit, the batteries, and the software. We consider out of the boundaries the HAN and the smartphone, although the cameras and the sensors are mostly included in it. For us it constitutes the payload. We think that the vehicles will be fully automatic in the future, and then that the ELV will be applied for both vehicles and mobile robots. To perform the LCA we have collected some data about of each component: mass, location of the producer, of the reseller, power consumption, the respect of European directives. But some data are missing like the lifespan, the possibility of reuse, details about the different subparts, etc. We tried to use data from “Traceparts” catalogue, which contains one of the biggest mechatronic component’s library and the LCA application “Bilan Produit” (ADEME). The missing data don’t allow performing accurate LCA. But all of the electrical and electronic components are produced using similar technologies, then the missing values could be evaluated using results of referenced works [5] [6] [7] weighted by the ratios of mass. So it appears possible to evaluate the attributional LCA (A-LCA) of a robot in the two configurations. The detailed results will be presented during the conference. We conclude that the central unit based on Arduino with the two added boards, has a half mass of the RPi solution (197g), and this last represents only the sixth of the total mass (1.250kg - 1.148kg). The power consumption of the Arduino solution is less the half of the other, both are little in comparison of the power needed by the mobile platform. The other impacts could be evaluated on the same way.

In the case of the software, because it can be modified during the use of the robot, we propose to perform a kind of consequential LCA (C-LCA). For instance we can proceed by comparison between versions of the software offering the same services, measuring the consumption and the lifespan of the material components, and the impact of the development and the distribution of it [8]. Some works indicate that the behaviour of the robot could be modified during the use to reduce dynamically the power consumption [9].

4. DISCUSSION AND POTENTIAL IMPROVEMENTS

This work was performed in a long time perspective. We would like to evaluate its feasibility. It appears that the A-LCA of the physical robot could be evaluated approximately. Currently the suppliers don’t deliver the needed data to make accurate LCA, but we can suppose that the catalogue of components will give these in the future. In the case of the software it seems that a kind of C-LCA should be more appropriate. The proposed comparative method should be tested on significant quantities of versions of the robot.

5. CONCLUSION

The sparse results of the survey and the lack of data about the components of the robot indicate that the LCA is not yet used in the robotics industry. Our work seems to come too early may be, but we think that this industry cannot avoid the use of LCA in the future.

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7. REFERENCES

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Résumé

L’émergence de la robotique au 21ème siècle a changé profondément notre relation avec l'environnement, mais a pour corollaire une consommation de matériaux, de ressources naturelles, et une production de déchets. Aujourd'hui, les robots sont produits en grand nombre, pour atteindre des flottes exprimées en millions. Ils touchent tous les aspects de la vie humaine pour assurer des services plus efficaces. Ainsi, la sensibilisation et les préoccupations environnementales, dans le domaine de la robotique, sont essentielles pour inciter les fabricants à développer des robots plus respectueux de l'environnement. À ce niveau, l'analyse du cycle de vie (ACV) est un outil utile pour améliorer les qualités environnementales des composants de robots et de réduire leurs impacts. Cependant, l'ACV en robotique, est coûteuse et complexe, car elle nécessite la disponibilité d’une grande quantité de données de bonne qualité, tout au long du cycle de vie, et par conséquent, implique tous les acteurs socio-économiques qui interviennent, de l'extraction des matières premières à la fin de vie du produit. Elle est également délicate car il faut prendre en compte les impacts générés par les composants mécaniques et électroniques ainsi que les flux de données traités par la plate-forme logicielle, qui joue un rôle principal dans la production d'impacts par le matériel lors de son utilisation.

Dans la première partie de cet article nous présentons les résultats d'une enquête réalisée sur 33 sociétés françaises de robotique avancée. Elles ont été interrogées sur leurs considérations environnementales et leur utilisation de l'ACV. Dans la deuxième partie, nous décrivons une étude de l'analyse du cycle de vie fait sur un cas de robot compagnon. Ce dernier a été construit au laboratoire Lab-STICC, en vue d’assister les personnes âgées et les aider dans leur vie quotidienne. Dans cette étude, nous comparons deux alternatives en utilisant deux types de processeurs différents. Nous avons tenté d’utiliser les données du catalogue "TraceParts", qui contient une des bibliothèques de composants mécatroniques les plus grandes, et le logiciel " Bilan Produit " proposé par l'environnement et l'Agence française de gestion de l'énergie (ADEME). Les résultats et l'analyse sont discutés et les améliorations envisageables sont proposées pour les travaux futurs.